Small Business Innovation Research/Small Business Tech Transfer

Tiled Silicon-Photomultiplier Array Read-Out Integrated Circuit, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

Silicon photomultipliers (SiPMs) are on the verge of revolutionizing all low light sensing and photon counting applications. The combination of low cost, compact size, and miniscule power consumption offers an attractive replacement for expensive, bulky, and power-hungry photomultiplier tubes (PMTs). SiPM laboratory setups typically include a bench full of heavy test equipment. The associated cost, size, weight, and power (c-SWaP) of this additional equipment present many practical challenges to the deployment of SiPMs, particularly in airborne and space missions.

Many applications benefit from a large tiled array of SiPMs. However, a large SiPM array presents a challenge in proper signal conditioning and handling large volumes of data. The key to solving this challenge is a complete read-out integrated circuit (ROIC) that takes the quantized analog signal from the SiPM array and converts it into useful digital data for the user. This ROIC not only manages the SiPM array data but does so in a manner that significantly reduces the associated c-SWaP from a benchtop solution, a key requirement for practical SiPM deployment.

The ultimate goal of this proposal is a fully integrated ROIC that interfaces to a SiPM array and is readily adaptable to both airborne and space deployed systems. The objective of Phase I is to develop the requisite components of a ROIC for photon counting and to assemble these components into a single channel of the ROIC. A test chip will be developed in Phase I to mitigate the risk of subsequent phases. This test chip will contain the relevant ROIC components, as well as a single channel of the ROIC, and will be designed, laid out, fabricated, and characterized in the Phase I effort.

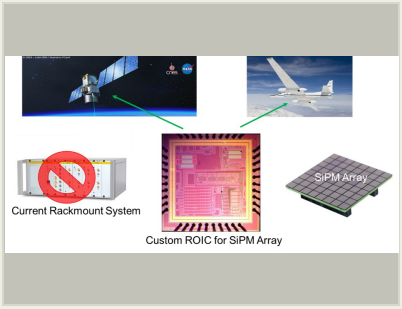
Anticipated Benefits

Potential NASA applications primarily center around LIDAR, which is expanding into a wide variety of uses. NASA has significant requirements for the use of LIDAR systems, an example of which is the CALIPSO mission for studying clouds and atmospheric aerosols. The Freedom Photonics SiPM ROIC will enable and enhance the miniaturization of LIDAR to the point that it can be easily mounted on a drone. The cost of airborne LIDAR surveys will be significantly reduced by moving to a drone platform.

There is great interest in using silicon photomultipliers (SiPM) in many low light sensing and photon counting applications, such as:

Airborne LIDAR surveys benefiting government agencies. For example, the USDA can use drone mounted LIDAR to optimize fertilizer and pesticide application to farmland.

There are also significant commercial applications for this product. By far the largest commercial market that has a need for the ROIC product developed by Freedom Photonics is medical imaging.



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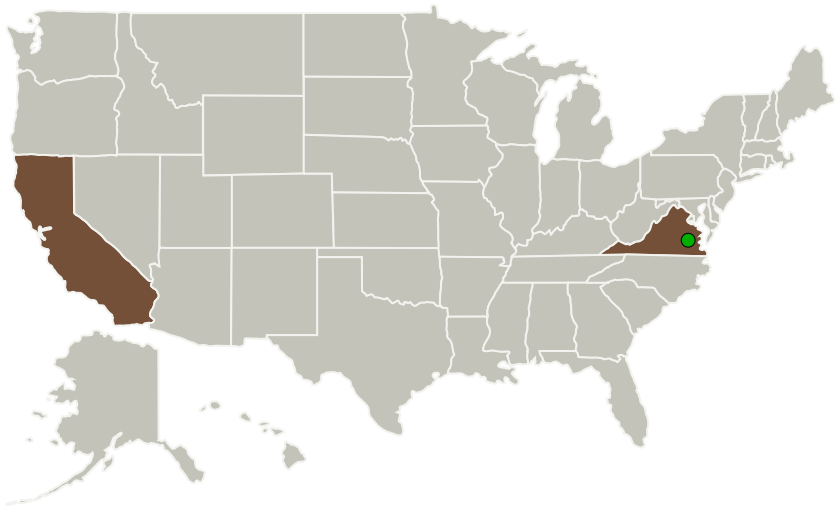
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Freedom Photonics, LLC	Lead Organization	Industry	Santa Barbara, California
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
California	Virginia

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139539)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Freedom Photonics, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

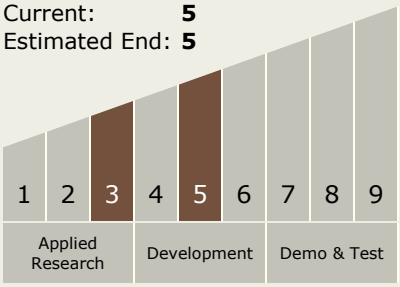
Carlos Torrez

Principal Investigator:

Daniel Renner

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



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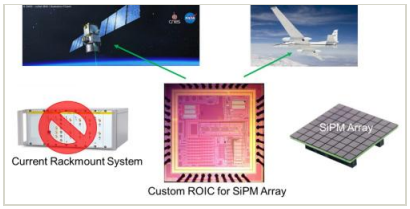
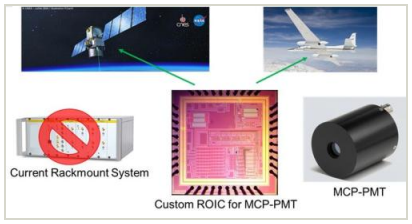
Images



Briefing Chart Image
Tiled Silicon-Photomultiplier Array Read-Out Integrated Circuit, Phase I
(https://techport.nasa.gov/image/126098)



Final Summary Chart Image
Tiled Silicon-Photomultiplier Array Read-Out Integrated Circuit, Phase I
(https://techport.nasa.gov/image/131745)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers

Target Destinations

Earth, The Moon, Others Inside the Solar System